

## Palladium-catalysed Dehydration of Propynyl Alcohols with Tin(II) Chloride

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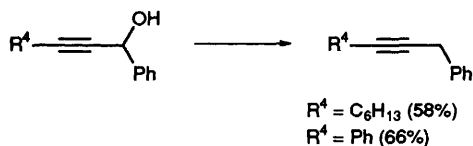
$\alpha,\gamma$ -Disubstituted propynyl alcohols having a proton on 1-position of  $\alpha$ -substituent have been dehydrated using  $\text{PdCl}_2(\text{PPh}_3)_2$  and  $\text{SnCl}_2$  in 1,3-dimethylimidazolidin-2-one under neutral conditions to produce 1,4-disubstituted (*Z*)-but-3-en-1-yne stereoselectively.

The (*Z*)-3-en-1-yne skeleton is found in a variety of natural products and has been constructed by various synthetic methods.<sup>1</sup> However, dehydration of  $\alpha,\gamma$ -disubstituted propynyl alcohol, easily derived from 1-lithioalkyne and aldehyde, forming the (*Z*)-3-en-1-yne skeleton has not been

reported. We report here the stereoselective synthesis of 1,4-disubstituted (*Z*)-but-3-en-1-yne by palladium-catalysed dehydration of  $\alpha,\gamma$ -disubstituted propynyl alcohols with  $\text{SnCl}_2$  under neutral conditions. Allylic alcohol cannot be transformed into  $\pi$ -allylpalladium complex with  $\text{Pd}^{\text{II}}$  complex



**Scheme 1** Reagents and conditions: substrate (1 mmol), PdCl<sub>2</sub>(PPh<sub>3</sub>)<sub>2</sub> (10 mol%), SnCl<sub>2</sub> (1.5 mmol), DMI (1.5 ml), 70 °C



**Scheme 2** Reagents and conditions: substrate (1 mmol), PdCl<sub>2</sub>(AsPh<sub>3</sub>)<sub>2</sub> (10 mol%), SnCl<sub>2</sub> (1.5 mmol), H<sub>2</sub>O (10 mmol), DMI (1.5 ml), 50 °C, 22 h

under the same conditions as those of allylic ester but can be with SnCl<sub>2</sub>, and the formation of  $\pi$ -allylpalladium complex from allylic alcohol has been applied to carbonyl allylation.<sup>2</sup> Using a base, allylic esters can be transformed into 1,3-dienes via the formation of  $\pi$ -allylpalladium complex followed by the abstraction of a  $\beta$ -proton.<sup>3</sup> Thus, we investigated the formation of allenylpalladium complex<sup>4</sup> from propynyl alcohol and Pd<sup>II</sup> complex with SnCl<sub>2</sub> and the abstraction of the  $\delta$ -proton of allenylpalladium complex, using 1,5-diphenylpent-1-yn-3-ol as a propynyl alcohol, under various conditions. PdCl<sub>2</sub>(PPh<sub>3</sub>)<sub>2</sub> and PdCl<sub>2</sub>(AsPh<sub>3</sub>)<sub>2</sub> are effective for the formation of allenylpalladium complex followed by the abstraction of a  $\delta$ -proton, namely the dehydration of propynyl alcohol, with SnCl<sub>2</sub> to afford (*Z*)-1,5-diphenylpent-3-en-1-yne in 1,3-dimethylimidazolidin-2-one (DMI) at 70 °C for 48 h in 31 and 11% yields (*E*:*Z* = 20:80), respectively. No reaction occurred with PdCl<sub>2</sub>(dppe), PdCl<sub>2</sub>(dppp), PdCl<sub>2</sub>[P(OPh)<sub>3</sub>]<sub>2</sub>, PdCl<sub>2</sub>(PhCN)<sub>2</sub> and PdCl<sub>2</sub>(py)<sub>2</sub>.<sup>†</sup> Solvents such as methanol, acetone and tetrahydrofuran were also not effective. It was found that both PdCl<sub>2</sub>(PPh<sub>3</sub>)<sub>2</sub> and SnCl<sub>2</sub> were necessary for dehydration to proceed under the same conditions. The best conditions were applied to the dehydration of various propynyl alcohols (Scheme 1). Representative results are summarized in Table 1. Propynyl alcohols bearing a 3-aliphatic substituent reacted faster than those bearing a 3-aromatic substituent (entries 1 and 3, and 6 and 7). The (*Z*)-3-en-1-yne isomer was preferentially produced in every case (*E*:*Z* = ca. 2:8).

<sup>†</sup> Abbreviations used: dppe = 1,2-bis(diphenylphosphino)ethane; dppp = 1,3-bis(diphenylphosphino)propane; py = pyridine.

**Table 1** Palladium-catalysed dehydration of various propynyl alcohols with SnCl<sub>2</sub>

Entry	R <sup>1</sup>	R <sup>2</sup>	R <sup>3</sup>	t/h	Yield (%)	<i>E</i> : <i>Z</i> <sup>a</sup>
1	C <sub>6</sub> H <sub>13</sub>	C <sub>5</sub> H <sub>11</sub>	H	26	66	23:77
2 <sup>b</sup>	C <sub>6</sub> H <sub>13</sub>	C <sub>5</sub> H <sub>11</sub>	H	95	67	18:82
3	Ph	C <sub>5</sub> H <sub>11</sub>	H	50	67	16:84
4	Ph	Me <sub>2</sub> CH	H	73	79	18:82
5	Ph	PhCH <sub>2</sub>	H	91	53	20:80
6	Ph	(CH <sub>2</sub> ) <sub>5</sub>		96	34	—
7	C <sub>6</sub> H <sub>13</sub>	(CH <sub>2</sub> ) <sub>5</sub>		26	46	—

<sup>a</sup> The ratio was determined by 270 MHz <sup>1</sup>H NMR (JEOL GX-270).

<sup>b</sup> The reaction was carried out at 50 °C.

Propynyl alcohols, bearing no 1-proton on the  $\alpha$ -substituent, such as 1-phenylnon-2-yn-1-ol and 1,3-diphenylprop-2-yn-1-ol were reduced with PdCl<sub>2</sub>(AsPh<sub>3</sub>)<sub>2</sub> (10 mol%) and SnCl<sub>2</sub> (1.5 equiv.) in DMI at 50 °C for 22 h in the presence of H<sub>2</sub>O to produce the corresponding propynes in 58 and 66% yields respectively (Scheme 2).<sup>5</sup> Adding D<sub>2</sub>O instead of H<sub>2</sub>O, 1-phenylnon-2-yn-1-ol was converted into 1-deuterio-1-phenylnon-2-yne.

The dehydration (R<sup>1</sup> = C<sub>6</sub>H<sub>5</sub>, R<sup>2</sup> = C<sub>5</sub>H<sub>11</sub>, R<sup>3</sup> = H; 50 °C, 26 h, 49%) and the reduction (R<sup>4</sup> = C<sub>6</sub>H<sub>13</sub>; 50 °C, 12 h, 51%) of propynyl methyl carbonates with Pd<sup>II</sup> catalyst and SnCl<sub>2</sub> are faster than those of the corresponding propynyl alcohols. However, using propynyl alcohol as a starting material is a great advantage for the dehydration and reduction reactions, because propynyl carbonate is usually prepared from the alcohol.

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